MAGNETIC HEAD AND DISK X-Y TEST ASSEMBLY WITH OPTIMIZED ARRANGEMENT FOR SKEW ANGLE

Field Of The Invention

(001) The present invention relates to magnetic recording, particularly to a magnetic head and disk tester.

Background

(002) A magnetic head and disk tester is an instrument that is used for testing the characteristics of magnetic heads and disks such as signal-to-noise ratio, pulse width and so on. Each tester includes two main assemblies, i.e., an electro-mechanical assembly that performs movements of a head assembly with respect to a disk, and an electronic assembly that is responsible for measurements, calculations, and analysis of the measured data.

(003) In many known magnetic head and disk testers linear movements are used to achieve proper positioning of a magnetic head with respect to a magnetic disk mounted on a disk spindle. For example, the magnetic head and disk tester disclosed in U.S. Pat. No. 4,902,971 to Guzik et al. uses only one (X-axis) movement. As a result, a proper skew angle is achieved only on inner and outer tracks. On other tracks the skew angle is close but not equal to the required value.

(004) Positioning mechanisms employing linear X–Y movements are also utilized in the field of magnetic head and disk testing, for instance in the E5013A spin stand by Agilent Technologies. These mechanisms use separate sliders on X and Y-axes. The main disadvantage of known X–Y positioning mechanism is the strict demands this method impose on the control of head moving mechanism. For instance, as explained below, it may require a complex geometrical path over which the head travels across the surface of the disk. In some situations no simple mechanical provisions exist to prevent the head from crashing into the hub of the disk spindle.

Definition of Terms

(005) The parameters used to characterize the head position with respect to the magnetic media (Fig. 1) are:

• The **track radius** R is the distance between the head write/read element and the center of the disk.

• The skew angle α is the angle between the head longitudinal axis and track tangential direction at head position over a magnetic head having concentric tracks.

(006) A typical X-Y head manipulator allows for selecting two head coordinates X and Y. Thus, during head positioning one must select the values of X and Y to achieve a given R and α.

(007) Fig. 1 shows the typical head trajectory in a prior art tester from the outer track (radius R_1) to the inner track (radius R_2) for a tester, where the skew angle at each track is equal to the skew angle in a disk drive with a rotating head loader arm.

(008) Fig. 2 shows a typical arrangement of a prior art X–Y positioning mechanism in a two head (top and bottom) tester which maintains the head longitudinal axis parallel to the Y-axis. In the configuration of Fig. 2, top and bottom heads are tested on the same surface of the disk (note that when the bottom head is tested, the direction of disk rotation is reversed). For the top head, following equations relate head coordinates to track radius and skew angle:

$X = X_0 + R\,\mathbf{cos}(\alpha)$, and

$Y = Y_0 + R\,\mathbf{sin}(\alpha)$,

(009) where X_0 and Y_0 are the coordinates of the center of the disk. Here we assume counterclockwise rotation of the disk. The skew angle α is measured counterclockwise from the head longitudinal axis to the tangential direction of the track at head position.

(010) One can impose a horizontal limit ($X > X_0 + S$) for the head movement to avoid hitting the hub with the head or the head-supporting arm. Here S is the minimal distance between head write/read element and the center of the disk.

(011) In a typical case ($R_1 = 0.75"$, $R_2 = 1.75"$, $\alpha = 20°$) the range of X-movement required to follow the disk drive simulating trajectory is approximately 0.94" and the range of required Y-movement is about 0.86".

(012) As can be seen from Fig. 2, to move the head from the top head testing area to the bottom head testing area a complex head trajectory should be used (called "proper" trajectory on Fig. 2) to bypass the spindle hub. A software error may cause choosing a wrong trajectory and crash the head and head-loading arm into the hub ("crashing" trajectory on Fig. 2)

(013) The geometry of head movements discussed above has some fundamental disadvantages from the mechanical point of view:

- A simple error in control software may cause the head and head loader arm to crash into the spindle hub. No simple mechanical protection is possible.

- Long vertical (Y) movements may be not desirable due to mechanical concerns, for instance, head loader arm has to be long enough to reach across the disk.

(014) It is accordingly an object of the present invention to provide a magnetic head and disk tester, which is simple in construction, reliable in operation, and universal in application.

(015) It is a further objective to provide a test assembly that avoids the possibility of crashes at a head support assembly and the hub of a tester. Other advantages and features of the invention will become apparent from a consideration of the ensuing description and drawings.

Summary of the Invention

(016) The present invention effects a simple path for a head across the surface of a disk and eliminates the possibility of crashing into the hub, even when moving to an unloading position, where the head must be far from the disk.

(017) This object is achieved by selecting an angle between the head mounted on an X–Y moving platform and the X-axis, to be not equal to 90° in such a way that X movement is mostly used to move the head across the magnetic media, and the Y movement is strictly limited so the head cannot crash into the hub even during movement to the unload position.

(018) The head loader may carry both top and bottom heads working on different surfaces of the magnetic disk. Alternatively, a V-shaped head loader may be used to mount top and bottom heads simultaneously and test them on the same surface of the disk, for instance to facilitate testing automation. For this head loader the bottom head is mounted symmetrically to the top head with respect to the Y-axis and is moved across the magnetic media by the same movement mechanism as the top head. This way the bottom head cannot crash into the hub as well.

Brief Description Of Drawings

(019) FIG. 1 is a schematic drawing showing a typical head trajectory in a prior-art head and disk tester.

(020) FIG. 2 is a schematic drawing of head trajectories and testing area of a prior-art magnetic head and disk tester with X-Y movement.

(021) FIG. 3 is a schematic representation of a magnetic head and disk X-Y tester according to the present invention.

(022) FIG. 4 is a schematic drawing showing a typical head trajectory in a head and disk tester according to the present invention.

(023) FIG. 5 is a schematic drawing of head trajectories and testing areas of a head and disk tester according to the present invention.

Description of the Preferred Embodiment

(024) A preferred embodiment of the invention, tester 300, is shown in Fig. 3. The tester 300 includes a massive rigid (e.g. granite) base plate 302, referenced to an X-Y coordinate system. A magnetic disk support and spindle extend from base plate 302 and support a rotatable magnetic disk 305. The disk 305 has a plurality of concentric of magnetic data tracks between an inner diameter track ID and an outer diameter track OD. In the illustrated form, an X-direction movement stage (X-stage) 306 is coupled to base plate 302 by an air bearing (not shown), for movement in the X direction in response to an X-drive motor (not shown). A Y-direction movement stage (Y-stage) 310 is coupled to the X-stage 306 by a linear roller bearing assembly (not shown). The Y-stage 310 (and stage 306) are adapted for motion relative to base plate 302 in the Y-direction in response to a Y-drive motor (not shown). Other types of bearings for the respective stages may be used in other embodiments.

(025) A cartridge 320 is affixed to the X-movement stage 306. A head gimbal assembly (HGA) extends from a distal end of cartridge 320, along an HGA longitudinal axis, A. The head gimbal assembly has at its distal end, a magnetic head assembly 326 with an integral read/write head.

(026) In accordance with the invention, the HGA longitudinal axis A is angularly offset by an angle ϕ with respect to the X axis. Preferably, the angle ϕ is 45 ± 20 degrees. In the illustrated embodiment, the offset angle ϕ is 45 degrees. In Fig. 3, lines 330 and 332 respectively show the –20 degree and +20 degree skew angle limits for the head assembly 326 (points A' and B', respectively). With this configuration, to traverse from point A' to point B', it is apparent from Fig. 3 that a relatively small Y-direction motion is required. This is particularly advantageous compared with the prior art, since the relatively small required movement allows use of a smaller and less costly Y-drive assembly. Further with the offset (due to angle ϕ), even if there were to be a failure (in software or electronics, for example), any resultant uncontrolled movement of the steps would not result in a crash into the spindle.

(027) In the embodiment of Fig. 3, a second (optional) cartridge 320A is also affixed to the X-movement stage 306. Cartridge 320A is similar to cartridge 320, except that it is mounted with angle ϕ' equal to –45 degrees. The arrangement with two cartridges (320 and 320A) permits testing for two heads with the same surface of the disk, while spinning the disk alternately in opposite directions.

(028) Thus, the present invention introduces an additional angle ϕ between the head longitudinal axis and the direction of the X-axis (see Fig. 4). In this case, assuming counterclockwise disk rotation, the relations between head coordinates and track radius and skew angle are transformed to

$$X = X_0 + R\,\mathbf{sin}(\phi + \alpha)$$

$$Y = Y0 - R\,\mathbf{cos}(\phi + \alpha)$$

(029) The angle ϕ is selected between 0° and 90°, that is, ϕ cannot be 90°). If ϕ = 90°, the head longitudinal axis would be parallel to the Y-axis and the configuration would correspond to the prior art configuration of Fig. 2.

(030) To avoid hitting the hub we can limit the range of vertical head movements is limited to $Y < Y_0 - S$.

(031) In typical case ($R_1 = 0.75"$, $R_2 = 1.75"$, $\phi = 45°$, $\alpha = 20°$) the range of X-movement required to follow the disk drive simulating trajectory is approximately 1.27" and the range of required Y-movement is about 0.14".

(032) The head cannot crash into the spindle hub during any X-movement due to the limitation of Y movement noted above. Simple mechanical limiters are used to restrict the required range of X and Y-movements.

(033) The bottom head can be tested at the opposite surface of the disk or a V-shaped head loader can be used to test top and bottom heads at the same surface of the disk (on Fig. 4 both heads are at the upper surface of the disk).

(034) The geometry of head movements in accordance with the present invention provides the following advantages from the mechanical point of view:

- There is a tradeoff between required range of vertical and horizontal movements. By changing the value of ϕ one can narrow the range of Y-movement while possibly widening the range of X-movement. This tradeoff allows finding the optimal value of ϕ to restrict vertical movement and completely avoid the possibility of hitting the hub while maintaining all necessary head trajectories. The X-movement range may be chosen wide enough to reach the unloading position.

- A V-shaped head loader with two heads may be used to test bottom heads on the same surface of the disk (Fig. 4) with opposite directions of disk rotation. The bottom head travels across the testing area with the same X-movements as the top head and the same Y-movement restriction are used.

- In the preferred form, the Y-movement range needed to simulate the skew angles in a disk drive is very small. In this case, it may be enough to approximate the required trajectory with a horizontal line and use only the X-movement, as in U.S. Pat. No. 4,902,971.

(035) While the invention has been particularly shown and described with reference to specific preferred embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.